

# T-Wave Alternans and Sudden Cardiac Death

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**Abstract:** Sudden cardiac death (SCD) is the leading cause of mortality in patients with ischemic heart disease and left ventricular dysfunction. The majority of SCD are due to ventricular tachyarrhythmias. SCD strikes many asymptomatic patients and often is the first manifestation of heart disease. Thus, reliable determination of arrhythmic risk is warranted to guide preventive therapy. To highlight the prognostic value of microvolt-level electrical alternans of the T-wave (MTWA) in patients at risk for SCD, most of the pertinent published articles in the Medline, Scopus, and EBSCO Host research databases have been reviewed. MTWA has been proposed to be a strong and independent predictor of all-cause and arrhythmic mortality. The high predictive value of MTWA in patient with cardiomyopathy varies significantly depending on the population studied. Combining with other indices or having serial MTWA readings could overcome MTWA limitations. Redefining MTWA readings may expand its prognostic utility.

**Key Words:** T-Wave alternans, sudden cardiac death, cardiomyopathy

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Sudden cardiac death (SCD) is the leading cause of mortality in patients with ischemic heart disease and left ventricular dysfunction.<sup>1</sup> SCD remains a major challenge in developed countries; it accounts for 11% of all deaths and ~50% of all cardiovascular deaths.<sup>2</sup> In the U.S. alone, nearly 300,000 patients experience SCD.<sup>3</sup> According to published data, the underlying arrhythmia in ~80% of cases of SCD was ventricular tachycardia (VT).<sup>3,4</sup> Several published studies have identified selected groups of patients at high risk for sudden death.<sup>5–7</sup> Despite these advances, most patients at risk are still not identified before their life-threatening arrhythmia. SCD strikes many asymptomatic patients and often is the first manifestation of heart disease. Thus, reliable determination of arrhythmic risk is warranted to guide preventive therapy.

There are many noninvasive indices, such as late potentials (LP) determined by signal-averaged electrocardiography (SAECG),<sup>8,9</sup> left ventricular ejection fraction (LVEF),<sup>8,9</sup> ven-

tricular tachyarrhythmias (VTs) determined by Holter monitoring,<sup>10</sup> heart rate variability,<sup>11</sup> and QT dispersion,<sup>12</sup> have been used to identify patients at risk for the development of ventricular arrhythmias. In particular, indices, which reflect abnormalities of depolarization and EF, have been shown to be predictors of ventricular arrhythmic events in patients after acute myocardial infarction (MI).<sup>8,9</sup> However, the predictive value (PV) of LP or EF alone in predicting future serious ventricular arrhythmias have low positive predictive values (17%–29%).<sup>8,9</sup> Recently, microvolt-level electrical alternans of the T-wave (MTWA) has been proposed to be a predictor of life-threatening ventricular arrhythmias.<sup>13,14</sup>

## T-Wave Alternans

MTWA is an ECG phenomenon defined as beat-to-beat alternation of the morphology, amplitude, and/or polarity of the T-wave.<sup>15</sup> It refers to alternation of the electrocardiographic ST-segment,<sup>13,16</sup> T- and U-wave.<sup>17</sup> Visible MTWA of increasing subtlety has been reported in patients with ischemia,<sup>18</sup> long QT syndrome (LQTS),<sup>19</sup> electrolyte disturbances, and conversion from tachycardia,<sup>20</sup> and consistently linked with VTs.<sup>21,22</sup> The use of MTWA relies upon microvolt level fluctuations that are invisible to the eye but required computerized signal processing methods to be demonstrated.<sup>16,23,24</sup> In some cases, MTWA performed better than SAECG<sup>19,25</sup> and electrophysiologic study (EPS) in predicting arrhythmic events.<sup>13,19</sup>

## T-Wave Alternans and SCD

Recently, MTWA has been considered as a promising new way of determining arrhythmia vulnerability.<sup>13,19,25,26</sup> Many studies link MTWA with inducible<sup>13,23</sup> and spontaneous<sup>18,19,27</sup> clinical ventricular arrhythmias, and with basic mechanisms leading to their initiation.<sup>28</sup> Kodama et al<sup>29</sup> reported that MTWA was sufficiently large as to be visible in 8% to 10% of patients with cardiomyopathy (CM) especially during episodes of emerging tachycardias or adrenergic stimulation with dobutamine. Another 2 studies<sup>21,30</sup> reported cases of spontaneous (ventricular fibrillation, VF) emerging from background of macroscopic MTWA during telemetered clinical monitoring. During ambulatory recording in patients, the amplitude of MTWA significantly increases 30 to 60 minutes preceding the onset of sustained ventricular arrhythmia.<sup>31</sup> The magnitude of repolarization instability, manifested by MTWA and beat-to-beat oscillations of T-wave amplitudes at other frequencies, increased before the onset of ventricular arrhythmias. Thus, MTWA is a direct measure of ventricular repolarization instability and it identifies a particular arrhythmogenic substrate in which hemodynamically well tolerated VT may degenerate into terminal VF.<sup>32</sup>

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